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The Politics of Technological Change: An Empirical Study

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Introduction

Developments in manufacturing and information technologies over the past decade have given rise to a substantial body of research and debate about the implications of technological change for employment, skill levels, and economic competitiveness. On one side, "postindustrial" and socio-technical theorists suggest that numerous factors -- including technological developments themselves -- are presenting business organizations with the opportunity (or, in the minds of some, the necessity) to fundamentally recast themselves in the direction of greater flexibility and responsiveness to market conditions. These attributes, they suggest, can only be achieved through a sea change in organizational approaches to the design and deployment of technology and human resources (cf., Piore and Sabel 1984; Walton 1987; and Hirschhorn 1984). It is argued, for example, that the potential benefits of new "informating" technologies (Zuboff 1982) can only be realized through the grant of greater autonomy and responsibility to employees formerly handcuffed by Taylorist definitions of automation; and, according to Hirschhorn (1984) and others [most notably Davis and Taylor (1976)], the greater complexity and sensitivity of new manufacturing technologies actually demand greater -- not lesser -- involvement, commitment, and skill from production workers. In short, technological and organizational "possibilities" are increasing in number. What remains at issue is whether managers (especially American managers) will grasp those possibilities.

On the other side, analysts working from marxian labor process theory suggest that neither technological developments nor hopeful scenarios are likely to shake managers from a philosophy and a practice aimed at cost reduction, deskilling, and enhancement in control over the work process. They point to the shopfloor use of new technology and question whether anything has changed -- even with the appearance of so many possibilities. In particular, Braverman's (1974) depiction of the "control imperative" argues that managers use technology to deskill the labor force and thus render it more subject to external control. In the wake of his work, a host of case studies have been compiled which, while not necessarily refuting the

postindustrialists' reports of new developments, certainly cast shadows on the latters' claims of the urgency or necessity of a philosophical and practical shift in management. Noble (1984), for example, documents the winnowing of possibilities that took place with the development of numerical control equipment and argues quite adamantly that options which might have allowed machinists greater influence in the conduct of their work -- a frequently cited possibility attributed to new technology (cf., Hirschhorn 1984) -- were discarded in the interest of greater managerial control over the labor process. Shaiken (1986) and Howard (1987) reach similar conclusions in their overviews of technological change in manufacturing industries.

To date, the evidence about job loss and creation, skilling and deskilling, and competitiveness and stagnation has not yielded anything resembling a clear pattern of outcomes (cf., Hunt and Hunt 1985; Francis 1986; Jones 1982; Kelley 1986; Spenner 1987; Piore and Sabel 1984). Part of the confusion in the debate over the consequences of new technology, as well as the variability in choices organizations have, resides in the complex definitional and methodological issues the topic surfaces: how jobs are counted, how skill changes are measured, and how competitiveness -- organizational or industrial -- is operationalized.

But, equally important, the debate over what is happening -- much less the debate over what might happen -- has also been hampered by a relative lack of attention to the actual processes by which organizations select and implement new production technologies. Failure to thoroughly investigate the process and the context of organizational decision-making around new technology has led to a situation in which a great deal is assumed (by theorists on both sides) about: (1) managerial rationality or irrationality in problem-selection and problem-solving; (2) the relative influence of economic and political/ideological criteria in decision processes; and (3) the intentions or objectives which decision-makers seek to fulfill through technological change.

In this paper, the results of two comparative case studies of technological change in a major manufacturing company -- a flexible machining cell and shop programmable machine

tools -- argue that the process whereby organizations select and implement new production technologies is an inherently political one. But, by contrast to prior characterizations (e.g., Pettigrew 1973, Dean 1987), I will argue that the politics of decision-making ought not be seen as limited to the process of jockeying, lobbying, coalition-building, etc., associated with securing approval for (or denying) a change proposal. To be sure, the case studies will show that the framing of proposals and the justification of change are rife with partisan activity and frequently contradict the tenets of rational behavior put forth by neo-classical economics (cf., Simon 1955; March 1978). However, there is another level of politics below the surface which is intimately tied to the structure of power and authority in organizations. This level of politics may prove no more rational (at least in the dictionary sense); but, I will argue, it does provide a plausible alternative to both the indeterminacy of simple models of "pluralism" in organizational politics and the over-determinism which tends to characterize most renderings of labor process theory.

This structural dimension to the politics of technological change is most clearly revealed in two stages. The first stage involves an analysis of the objectives or interests which underlie proposals for (and opposition to) change. Three categories of objectives will be put forth as critical: (1) personal objectives or the interests which individual proponents and opponents seek to promote or protect in the change process; (2) positional objectives or interests associated with functional distinctions within organizations (e.g., between production and sales units; top, middle and lower management; or management and labor); and (3) organizational objectives or interests emblematic of the enterprise as a whole and its relationship to the external environment, including its competition.

Technological change options, I will argue, are filtered through a three dimensional screen created by personal, positional and organizational objectives. Independent of whether the proposed change is generated internal to the organization or drawn from the outside (e.g., from a vendor), it will not pass through the screen (i.e., be implemented) unless there is at least

minimal alignment among those three objectives. Thus, we can expect that a great deal of effort associated with technological change will involve proponents' attempts to create the appearance, if not the reality, of alignment. Most commonly, proposals will be framed in terms of their contributions to organizational objectives precisely because those objectives will constitute the language of discourse within the organization itself. Personal and positional objectives will either be presented as subordinate to overarching organizational objectives or as dwarfed by comparison to the overwhelming significance of the organizational objectives. This constitutes the core of what Dean (1987) has referred to as the "justification" process.

The second stage, however, involves an analysis of the models which underlie the objectives and the relationships which influence the choice of models. Since the justification process is only activated _after_ problems are "found" (Pounds 1969), it is essential to illuminate the models of present and desired states which guide what Lyles and Mitroff (1980) refer to as the process of "problem formulation" for different categories of organizational actors. In other words, I will suggest that the analysis of proposals for change must be accompanied by an analysis of the more general models which guide or direct the identification of the problem itself. However, problem formulation does not occur in a vacuum. It involves reflection on the activities and behaviors of other organizational actors -- be they subordinates, peers or superiors. More importantly, aside from the purely technical aspects of production (e.g., the characteristics of the raw materials undergoing transformation), alterations in production technique invariably involve _changes_ in the behaviors of human beings. The key "problem" which anchors this analysis of models is what I will refer to as the "human problem of transformation", i.e., the transformation of the "potential to work" which organizations acquire when they hire employees and the actual output (in products or services) which employees create.

Thus, I will argue, _relationships_ among categories of organizational actors, particularly power relationships, and _ideological positions_, particularly differences in perspective on what

motivates human beings, will directly influence the identification of problems and the choice of solutions. By contrast to the postindustrial perspective, I will suggest that the proliferation of "technological possibilities" alone is unlikely to alter managers' models of the human problem of transformation -- that will require a substantial shift in both ideology and practice. But, by contrast to the labor process perspective, I will suggest that the human problem of transformation is not limited to production work or production workers -- in fact, it is often the basis to top management's model of the rest of the organization, including line management and staff.

Following a brief discussion of the rationale for studying technological change at the level of the firm, I will describe the research sites and the methods employed in the study.

Decision-Making around New Technology

Research and theory-building of the sort described in this paper hinges on two core assumptions: (1) Organizations selectively respond to change pressures emanating from within and from without. Ecological (Hannan and Freeman 1974), institutional (Zucker 1977 ; DiMaggio and Powell 1983) or systemic constraints (Edwards 1979; Gordon, Reich and Edwards 1982) may limit the array of responses available to a given firm at a given point in time; yet, organizations can and do select responses and transform them into empirically observable actions. (2) Characterization of the decision-making process as "organizational" does not imply that decisions (especially those which result in concrete actions) require either the participation or the consensus of all organizational actors. Indeed, the exclusion of some categories of actors is an important a part of the politics of decision-making (cf., Pettigrew 1973; Pfeffer 1977). However, by contrast to cognitive or psychological approaches to the study of decision-making (cf., Kleinmuntz 1987), the organizational aspect is important in that it forces us to take into account both the process and the context in which change decisions are made and it suggests that the organizational decision process, especially in large-scale firms, cannot be modeled in the same fashion as that of the individual decision-maker.

There are three specific advantages to the study of decision-making around new technology at the level of the firm.

First, it allows for the possibility that firms not only are capable of recognizing alternative technological possibilities but are able to select among those possibilities in line with a conscious or semi-conscious philosophy of work organization. At the same time, however, it allows for the possibility that decisions about technology are not strictly rational in the neo-classical economic sense -- that is, they are characterized by a bounded or limited rationality (March 1978) of a form which is essentially political (as the labor process theorists suggest) or philosophical (as the postindustrialists suggest). The nature of those boundaries or limits ought to be visible in the arguments (and data) marshalled in support or opposition to a proposed change. This firm-level approach to the study of technological change builds off earlier work in the politics of organizational decision-making, especially that of Pettigrew (1973) and the more recent study by Dean (1987). However, the approach I will use differs in one important respect: rather than conceptualize the "decision to innovate" (Dean 1987) primarily as a contest among individual managers or groups of line and/or staff employees, I will seek to uncover the "problems" -- discrepancies between the managers' models and organizational realities (Pounds 1969) -- which give rise to proposals for technological change.[1]

Second, a focus at the level of the firm throws into relief the process through which technological possibilities are surfaced (e.g., how information is collected, filtered, and bundled into proposals for change). If, as postindustrial theory suggests, the array of possible approaches to work organization is expanding as a result of new developments in technology, then it will be of more than passing interest to see where and how knowledge of technique or precedent enters organizations. By contrast, if we follow labor process theory, the information collection and filtering process is likely to be severely constrained to include only those processes which allow visible cost reduction or some enhancement in management's ability to

control the production process. Filtering, in either case, ought to involve some assessment of the probabilities of success and failure of particular change proposals (Cyert, Simon and Trow 1956). Thus, explanation of what determines the perceived probabilities of success in a given change becomes a key to understanding the decision-making process.

Third, this approach forces us to investigate the process of technological change from concept to and through implementation. Although arbitrary starting and ending points are unavoidable and may underestimate the influence of past (or concurrent) decisions and post-implementation alterations (cf., Rice and Rogers 1979; Kazanjian and Drazin 1986), the emphasis on decision-making as a continous process of selection, testing and reformulation makes it possible to avoid one of the most serious shortcomings of much of the work done in the labor process tradition: the tendency to infer from outcomes to process. This weakness has been particularly evident in the many of the case studies inspired by Braverman's popular work: a tendency to undertake a cursory comparison between work organization under a new technology with the system which preceeded it and to claim not only that skills and/or control have been altered in the direction predicted by the theory, but that that outcome was precisely what management wanted (cf., Thompson 1982; Child 1985; Kelly 1985; Wood and Kelly 1982). One irony of this approach has been the tendency to attribute to management far greater rationality, consistency, and, indeed, omniscience, than most management scholars (e.g., Drucker 1988) would be willing to cede.

Research Sites and Methods

To more thoroughly examine organizational decision-making around new production technology, I undertook research in a Fortune 100 aircraft, aerospace and electronics manufacturing enterprise in the summer of 1987. The company employs nearly 100,000 people in the United States and Canada has contracts with three major North American unions. The union which also agreed to participate represents nearly two-thirds of the company's hourly employees in the U.S. [2]

Two recent technological changes were chosen to represent new but substantially different technologies being applied in the company's major manufacturing facilities.[3] They were also chosen for their "generic" qualities, i.e., their similarity to technologies being developed or applied in a wide range of manufacturing enterprises. The projects became the vehicle for analyzing the decision-making process.[4] Although the project unit focuses attention on the specific technology divorced from a stream of efforts of which it might be only one example, this approach allowed us to investigate a case from beginning to end (i.e., from concept to and through implementation).

Conditions of access made it necessary to choose technological changes which were, for the most part, already completed. Since post-factum analyses can fall prey to the reconstructive biases implicit in participants' recollections (cf., Schwenk 1985; Witte 1972; and Tversky and Kahneman 1974), the research was conducted in such a way as to separately (a) document the chronology of events surrounding the change in question and (b) query participants about their role and their objectives in the process. More specifically, data collection consisted of three main activities:

(1) In-depth semi-structured interviews were conducted with participants in the decision-making and development processes. Initial interviews were conducted with division-level research and development (R&D) managers to determine who was involved in the various phases of each project. Subsequent interviews included additional people who were mentioned by those interviewed on recommendation of R&D management. Thus, it was possible to expand beyond the central engineering personnel to include representatives of allied functions (e.g., facilities maintenance, materiel and purchasing, industrial engineering, training, and industrial relations). Later interviews were conducted with corporate officials, line managers, supervisors, workers and union representatives in the facilities into which the projects were placed. The interviews focused on the history of each project and on the direct or indirect contributions each respondent made in that process. The interviews were tape-recorded and

transcribed. Each of the respondents was assured of anonymity in the reporting process and every effort has been made to insure the confidentiality of the interview transcripts and the comments, ideas, and criticisms they contain. The factual content, as well as further exploration of key items, was aided enormously by the opportunity to reinterview selected respondents. In all, a total of 54 people were formally interviewed in the research. An additional ten individuals were consulted informally or for short periods around specific issues.

(2) All available documentation associated with these projects was collected. This material included project proposals and comments, memoranda and letters circulated internally, purchase specifications, bids from equipment vendors, and capital equipment requests. Every effort was made to corroborate dates, events, and (where appropriate) disputes by means of existing documentation. On occasion this took the form of reviews of engineer's journals and notes, i.e., logbooks which many engineers kept to document their progress, the hours they devoted to given projects, and their comments on meetings and conversations. These latter materials were especially useful in annotating and occasionally clarifying official reports and schedules.

(3) Field notes were kept on the time spent in each site observing the equipment at work and questioning the operators, supervisors and technicians in attendance about the technology, particularly in terms of how it departed from past practices and how it affected adjacent processes. Records were also kept on tours, hallway conversations and phone calls. Taken together, these notes provided a measure of continuity to the analysis-in-progress and were especially useful in generating new questions and lines of investigation. In addition, briefings have been held (and will continue to be held) for the sponsors of the project. These briefings and the feedback received in them has proven an important opportunity for learning on the part of the sponsors and the author.

The cases will now be presented individually.

<u>The Flexible Machining System</u>

The automation of machining processes has been an area of great interest to engineers, managers and academics for well over two decades (cf., Bright 1958). However, the creation of <u>flexible</u> machining systems (or cells, referring to a series of machines linked to one another) is a relatively new development. Until recently, the complexities and high cost of sensor technology have made it uneconomic to automate a machining system unless the volume of parts being produced was high and the variability of the cuts was low. The combination of automated transfer equipment, remote sensing devices and computer-controlled or numerically-controlled machine tools made sense for production runs of ten thousand to a hundred thousand automotive crankshafts or engine blocks but not for 10 landing gear struts or 6 internal supports for the tail section of a helicopter. Thus, in 1980, a machining system "flexible" enough to economically produce several dozen different parts each with production runs of less than 50 parts per month represented a major departure from this company's prior experience and, arguably, put it at or near the leading edge of such developments in the industry.

A cursory description of the technological possibilities alone offers few clues as to why it might be attractive or how it might, in fact, be operationalized. Yet, a return to the two major perspectives presented earlier gives us some rough hypotheses about the potential attractions and the likely outcomes of a move in the direction of FMS technology. The FMS principals, in particular, have been pointed to by Piore and Sabel (1984) supportive of an emerging strategy of "flexible specialization" in manufacturing firms, i.e., the capacity to use the same equipment to produce small quantities of highly varied parts to meet internal and market demands. This strategy constitutes an about face from the familiar model of mass production with its heavy emphasis on long production runs and low part variability. But, as Davis and Taylor (1976) and Kern and Schumann (1984) point out, flexibility has implications far beyond the technical dimension. In particular, effective use of the technology requires the enhancement of employee skills, i.e., the ability to monitor and direct expensive and often sensitive equipment becomes an

essential ingredient of the strategy. Moreover, the creation of a more tightly-coupled production system brings with it what Perrow (1984) refers to as more complex interactions, i.e., the potential for errors, accidents and/or malfunctions to occur as back-up systems and adjacent (but indirectly linked) processes interact in unpredictable ways. The combination of expense, sensitivity, and complex interactions suggest that employees should not only be skilled but committed and responsible participants in the flexible machining system.

From the labor process perspective, automation -- flexible or otherwise -- has tended to be seen as a linear extension of management's effort to reduce costs and expand control over the work process through deskilling (cf., Gartman 1986; Edwards 1979). Shaiken (1985), though not explicitly echoing the labor process perspective, nonetheless argues that the application of FMS technology in the sites he observed generally diminished the discretion of machine operators and repudiated the significance of both their tacit and their certified skills. Noble (1984) argues even more strongly that such outcomes were precisely management's objective and that the displacement of control to computer programmers and engineers (whose software "drives" the machines) represented classic examples of deskilling. Thus, we would expect in this instance, as in the examples these authors cite, that the FMS would be motivated by and targetted explicitly at cost reduction and control.

<u>A First Look at the Outcomes</u>

The FMS cell put into operation in 1984 did depart in significant ways from the process which preceded it (a schematic rendering of the cell is provided in Figure 1). Three machine tools which were formerly operated as stand-alone profile mills are now linked by means of a power roller conveyor. The conveyor and the manual system controls are operated from a single station ("operator console") on the off-side of the conveyor loop. TV monitors located at the operator's console show what is happening inside the safety shrouds of each machine. The entire system is integrated by a computer located in a room directly off the factory floor. The computer not only directs cutting angles, the speed of the various tools, and the rate with which

the pieces are fed into the machine, it also monitors (in real time) the actions of each of the three machining centers.

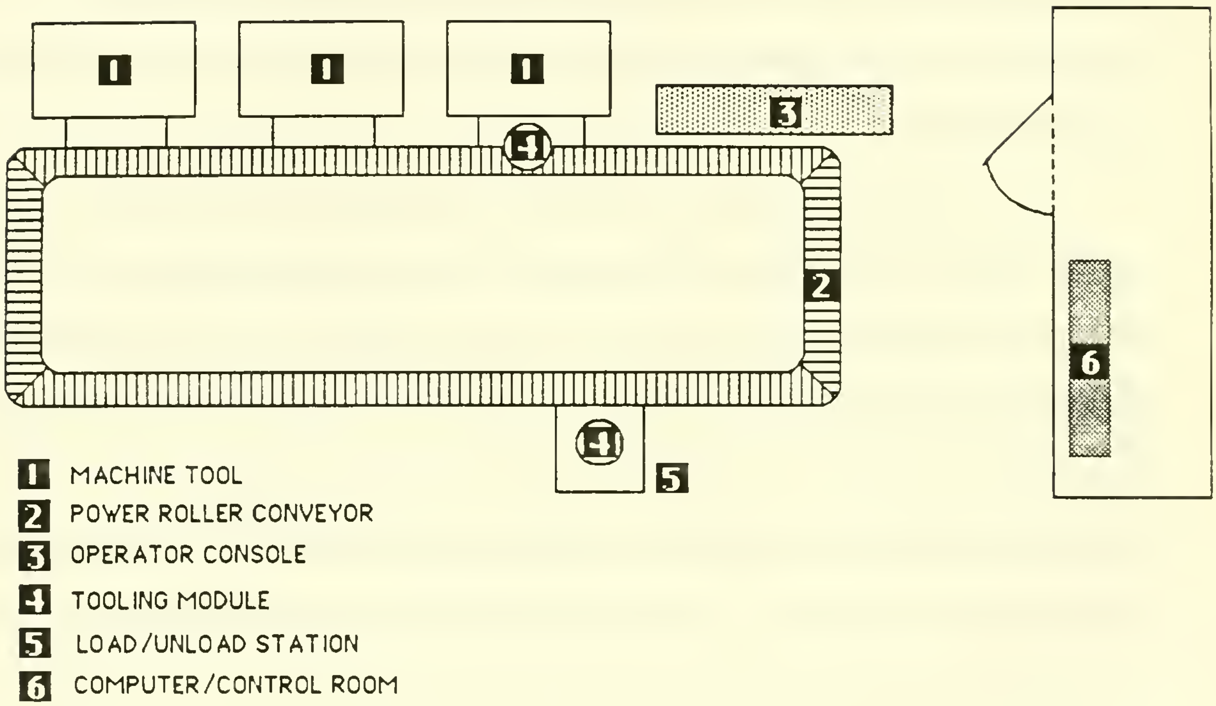
Figure 1: Diagram of FMS here

The FMS cell is operated by a single "operator," a union machinist. The computer driving the system is operated by a single non-union technician. The overall system is formally directed by a first-line supervisor. When brought up to capacity, the FMS cell replaced six machinists who had been operating the 3 machining centers as individual NC machines (across two shifts) with two operators. None of the machinists were laid-off as a result of the introduction of the new technology since work from other contracts enabled them to be absorbed elsewhere in this plant.

On the surface, this description of the changes brought about by the new technology does not offer decisive support for either the postindustrial or labor process perspective. On the one hand, the FMS certainly does represent a more expensive, sensitive, and complexly interactive system. The single operator who monitors the equipment while it runs still makes adjustments but now must also have a working knowledge of the entire system, particularly as breakdowns in any part (e.g., one machine tool) can impair overall performance. Machine repair personnel and programmers who provide technical support have had to become familiar with sensor technology in order to keep the system running and solve the inevitable problems that result from intense and variable use of the cell. On the other hand, however, one operator now handles three machines. The operators's wage has not increased over that paid to the former (individual) machinists. Actual control of the system has been handed over to a separate salaried technician. The operator no longer exercises the broadly-based skills of the machinist; for example, sensors govern the placement of parts and determine when cutting tools are to be replaced.

This mixed set of outcomes -- as well as the choice to proceed with an FMS in the first place -- demand an investigation of the process which intervened between concept and

FIGURE 1: SCHEMATIC DRAWING OF FMS CELL (TOP VIEW)



implementation. As this instance will reveal, the technological possibilities offered the company a window for change in its system of work organization. However, efforts to promote personal, positional, and organizational objectives and to align them in such fashion as to garner corporate support resulted in a narrowing of alternatives -- first in the options for technological change and then in the actual configuration of the (FMS) option chosen. The analysis of how alternatives were narrowed will offer important insights on the politics of technological development and change; yet, as I will suggest, those politics are hardly pluralist. The outcome will be shown to have been heavily influenced by a model of control -- over people and process -- through technology.

From Concept to Implementation

In analyzing the FMS case, I will first provide a brief overview of the chronology and then return to discuss the internal dynamics of the decision-making and development process. The initial interviews and a review of the documentation yielded the chronology depicted in Figure 2.

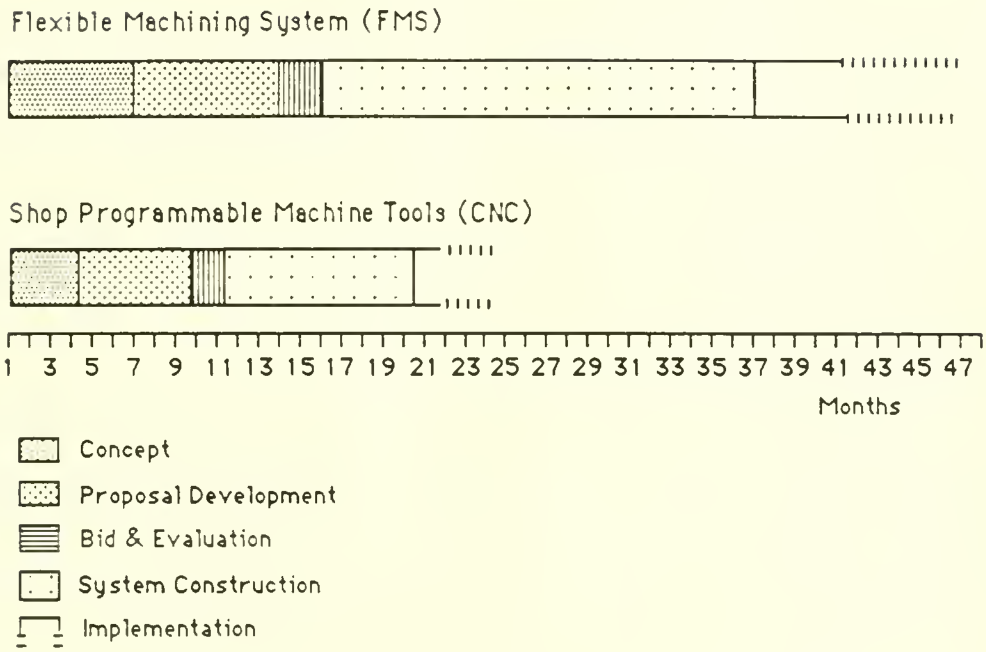
The bulk of the action pertinent to understanding technological decision-making in this case takes place during the first 14 months -- roughly the "concept" and "proposal development" stages.[5] During this time, a protracted "framing contest" took place. The divisional Research and Development (R&D) group, in several iterations, attempted: (1) to come up with a problem statement that could capture the attention of divisional management; (2) to make presentations to divisional management about what the problem was and then how their solution fit the problem; (3) to fend off efforts of other groups to redefine the problem; and (4) to work with divisional management to generate a convincing proposal which the division could then make to corporate management. After securing capital to make the purchases, and having vanquished other competitors in the framing contest, R&D turned to the extended process of delivering what it had promised. It finally turned to selling the FMS to the shop (i.e., the plant and its management) which would have to use the system.

Figure 2: FMS Chronology here

Even though it is in the charter of the R&D organization to develop newer and more efficient means to meet the production objectives of the division it serves, the research and development process does not proceed autonomously. Thus, while top management may not specify the technologies being developed or chosen, they do materially influence the opportunity to alter or advance production technology: first, through the performance criteria they establish for production management and, second, through the amount of capital they allocate for development efforts. Together, these are expressed as a set of overarching objectives and a language which enables different parts of the organization to communicate with one another.

In this case, the organizational objectives guiding divisional management and, by extension, R&D were one relatively straightforward: curb costs, increase productivity, and eliminate personnel (or, in the words of a highly-placed division manager, "lose heads"). A lengthy interview with the Manufacturing Manager for the division probed for his history of the FMS project to get a sense of the role played by corporate management in specifying the direction of production technology development. He was direct in his response: "Corporate doesn't exactly dictate which direction we ought to go. They're more influential when it comes to how much money we have to spend on new and replacement equipment. If you're given a budget of so many dollars, it's up to you to come up with the a scheme for making the best use of that money." This leads divisional management into a process of interpreting the organizational objectives set forth by corporate in terms of the performance criteria established for the division, the size of the budget alloted for capital equipment purchases, and the opportunities made possible (or impossible) by the amount of money available. In this instance, the Manufacturing Manager said he'd offered hints to his R&D people about what he felt were some of the major production problems in the division but that interpretation and those hints were largely "echos of the message we got from corporate," i.e., to cut costs and heads. In passing on the message to his staff, including but not limited to R&D, he said: "I sort of threw down the

FIGURE 2: Chronology of Activities in FMS and CNC Cases



gauntlet to my people to see who would respond."

The Framing Contest

The gauntlet arrived in the form of memo sent out in June of 1980. By October, two proposals were submitted. The first proposal called for a computer-controlled system with robot carriers to automate the storage and retrieval of parts in several shops. According to the proposal, the system would enable the shops to better track their inventory and, as a result, reduce the amount of (float) time that individual parts took in getting through the machining process. The proposal was put together by a pair of production superintendents who, by their own admission, were relatively unfamiliar with the details of such a system. Their suggestion, expressed in a terse two-page memo, offered little in the way of expectations for the cost of the system, the savings it might generate, or guidance as to who in the organization would take responsibility for overseeing its use.

The second proposal -- complete with transparencies and preliminary cost justifications -- came in from R&D. It urged consideration of a flexible machining system. The proposal carried with it a fairly dramatic framing of the problem: "...[O]f the total time a part spends in the shop, only 5% is spent on a machine. For the remainder of the time, the part is either waiting for processing or is in transit from one station to the next." Interviews with several engineers in R&D and other sources in the division revealed that, in some respects, the idea of an FMS was hardly coincidental. The proposal came close on the heels of the 1980 Machine Tool Show in Chicago which had featured the first fully-integrated FMS, a system created by a major equipment manufacturer. It also happened that several divisional engineers had attended the Machine Tool Show; at least one had gone with the explicit intent of viewing the FMS. Their estimate of machine usage closely resembled the phrasing that appeared in the brochures which extolled the virtues of the system on display.

Besides using a powerful sales brochure from the vendor, R&D added that the problems inherent in the present system of independently operated machines were two-fold. First, the

present system represented a material handling nightmare that could be resolved through a material handling system. An R&D engineer later recalled that several divisional managers, including the Manufacturing Manager, had complained that parts handling and tracking in several of the shops were "out of control." By invoking the same imagery, the proposal indicated that the problem did not reside in the machinery already in place. This was especially important since the machines in question were relatively new and purchase of a full FMS from a major vendor could cost in excess of $4 million. As one of the engineers involved in the development process told me: "We have the machines. They're just not working hard enough."

Second, R&D argued, the existing system was labor-intensive. This resonated with divisional management's interpretation of a key organizational objective. The FMS they proposed promised to "lose heads". And, at least as the vendors and various videotapes of Japanese factories had suggested, the system could do more than just eliminate some workers: it could be run unmanned. On several occasions I was told that managers returning from Japanese factories had marvelled at the sight of a shift of workers going home from the plant, turning off the lights, and leaving behind a factory "still chunking out the parts." At the very least, the FMS idea held forth the promise of reducing the number of workers in this part of the shop from 6 to one or two.

The Manufacturing Manager preferred the FMS proposal because "harder working machines" and fewer people were something his superiors could understand. The automated storage and retrieval system might have been equally helpful in solving material handling problems; however, it neither addressed the issue of machine running time nor promised to reduce the volume of direct (production) labor. Equally important, the storage system was, in the opinion of the Manufacturing Manager, a "band-aid" because: "It didn't get to the heart of the action: getting control over the process by getting the parts in and out of the machines. You don't get that unless you have a way to keep bottlenecks like people and paper from getting in the way."

A closer look at the "heart of the action" gives substance to a theme familiar to the labor

process perspective -- control -- but it also reveals that the problem to which the Manufacturing Manager referred included but was not limited to workers. With respect to workers, the FMS offered the opportunity to eliminate the customary practice of allocating one machine operator per machine. Even with the proliferation of numerically-controlled machines and automated machining processes, the rule of thumb remained "one man-one machine." The FMS approach would challenge that rule since one operator could be running three machines. With respect to shop management and the social system of the shop in general, the Manufacturing Manager offered this assessment:

> It's hard for them (shop management) to see the real problems sometimes. They don't always see that they're part of the problem.... They have commitments to this guy or that way of doing things. My job is to get the work out. To keep things under control.

Thus, two themes, <u>control</u> -- over process and people -- and <u>myopic vision on the part of shop management</u> -- influenced greatly by the web of obligations and tradition that characterize social relations in production -- emerged as key ingredients of divisional management's positional objective.

There was, however, an additional appeal that coincided with a more personal objective for this manager: "I wanted to be the guy who did it first." In order to do it first, he argued that it had to be done right, done cheaply, and done quietly. Thus, he gave the go-ahead to R&D to begin investigating how other companies had approached the problem of setting up an FMS. Learning from others' mistakes could help it be done right and cheaply. But, he also cautioned R&D to proceed without fanfare. As he later told me, "Those guys [from a larger division] were looking over my shoulder all the time. If they had caught on to what I was thinking about, you can be sure they would have said they deserve to be the first ones with an FMS." Moreover, "doing it first" and "doing it quietly" were also justified by recognition that contract negotiations with the union would be coming up about the time the FMS became operational. Hence, management did not want the FMS to become the object of contract bargaining after money had been spent for

developing and procuring the equipment.

Aligning Objectives

The FMS proposal's success in the first phase of the development process might be easily summarized as the right idea at the right time, but beneath that simple statement resides an important insight. The FMS project had already undergone substantial massaging so that it could align several objectives at once: (1) organizational objectives -- at least as expressed in the common lore of the company -- by improving productivity and eliminating personnel; (2) divisional management's positional objective by solving what were perceived to be shop-level material handling problems resulting in machines and people "not working hard enough"; (3) divisional management's positional objective by quietly but effectively eliminating what was perceived to be an irksome staffing practice; and (4) the Manufacturing Manager's personal objective of being first.

The importance of objectives and their alignment was not, however, limited to corporate and divisional management. R&D had their own positional and personal interests. One of the principal engineers who was instrumental in proposing the FMS cited the significance of its technical possibilities and challenges. Inspired by what he had seen at the Machine Tool Show and learned from peers in other companies, he extolled the opportunities submerged in the proposal: "This gives us (R&D) the chance to be real engineers. To do what we do best, to do what we're trained to do, and to do what this company needs. We need to be at the front end of technological change." In a more personal vein, a colleague in the project added: "Projects like this don't come around that often. You have more of a chance to bring some positive attention to yourself when you're onto something new. It's not exactly a career-maker, but it sure doesn't hurt either."

However promising the proposal was in its initial form, success in the next stages of the proposal development process would depend heavily on the ability of R&D and, more importantly, divisional management to justify the FMS in the language of the organizational

objectives: projected economic performance as measured in "payback" or return on investment (ROI) calculations. The specific issue was staffing. Staffing questions would be intimately linked to the attractiveness or saleability of the proposal. A cross-country tour of FMS vendors and users had shown the R&D project group that the introduction of the FMS technology could generate considerable heat from workers and their unions. One engineer suggested that "even when you held constant the size of the cell and what they were making, the staffing solutions were all over the map." Staffing solutions ranged from less than one machine operator for every three machines to one person per machine. Another participant in the site visits told me that:

> We were warned against having hourly-paid persons involved in programming and configuration, among other things. [Another company] got into trouble with that. It was also a bone of contention over whether any of the jobs should have a higher classification or a higher grade.

The question of staffing <u>necessarily</u> carried over to the calculation of ROIs. According to the earlier engineer:

> I had to come up with a payback ... and the best I could come up with was four years. Around here, the corporate rule, the groundrule, is if the thing can't be paid back in less than two years, preferably one year, your request has a chance of a snow ball in hell of flying. Well now, that either makes you damned smart or a good liar.

The R&D manager, recognizing that part of the justification could not be easily stated in terms of a key organizational objective, sent the engineer off to work with staff in Industrial Engineering to come up with figures that would be more acceptable. Industrial Engineering staff helped generate more attractive figures, although when I sought to find out how those figures were arrived at, I was told that: "I'm not going to tell you how we generated that ROI because it was really silly. We had a number to hit and we hit it." The calculations were aided, according to one IE staff member, by the fact that "I was told that [the manufacturing manager] wanted the FMS and that was that."

R&D, with new calculations in hand, went back to divisional management. What should have been a 15 minute presentation, according to one observer, turned into a 3-hour working session. Divisional management liked the proposal on all the technical grounds but the staffing assumptions and, therefore, the ROI were not acceptable, particularly to those concerned about the discerning eyes of "corporate bean-counters." The staffing problem was resolved by making a supervisor the equivalent of the system operator. As I was told by the Manufacturing Manager:

> There was a lot of discussion as to who was going to operate them [i.e., the machines] and I very deliberately put a supervisor in charge ... not loading the fixtures, obviously, but to operate the computers to start it because I did not want my hands tied by the union.

He went on to add that: "I didn't want any problem ... and I didn't want to set a precedent for anybody else in the corporation that was going to put in an FMS." The change in staffing requirements thus enabled the assembled group to, in the words of one participant, "finesse the ROI."

Framing Outward, Upward and Downward

Once those changes were incorporated, the proposal was ready to be unveiled. Framing proceeded in three directions: outward to other allied and/or competing units; upward to the top levels of divisional management and to corporate management which reviewed fixed capital investments; and, finally, downward to the shop which would ultimately house the FMS. Given that the unveiling followed a substantial amount of work by the Manufacturing Manager and the R&D project team, framing was seen as a critical phase in the process. More importantly, as I will argue in the conclusion to this case, it further underscores the intimate relationship between technology and power in organizations.

Outward. The principal engineer on the project, the one who had been most directly involved in assessing the alternative directions the project could go, was sent along with several original members of the project team to make presentations to allied functions (e.g., the facilities and equipment maintenance department, resource planning, etc.) to "get them on

board." An NC programming supervisor who had been involved from the early stages of the concept to proposal development described the process:

> It wasn't anything new, really. You always wind up briefing a guy who doesn't really know what the hell he's talking about to send him up to another guy who doesn't know what the hell he's talking about, but may have heard enough pitches that he can ask some good questions and have some kind of expectations of an answer.

Resistance encountered along the way was focused less on the concept of the FMS, since R&D representatives came with the explicit backing of the Manufacturing Manager, than it was on the exact methodology to be employed in constructing the system. One functional group, which had itself been experimenting with the use of automated guided vehicles (AGVs), felt that AGVs were the way to connect the machines. Another group, which would have ultimate responsibility for maintaining whatever system was put in place, detested the AGV idea and countered with a proposal for the use of a power-roller conveyor. Since the conveyor offered to reduce the overall cost of the project and would stifle the resistance of the facilities group, a decision was made to go with the conveyors.

Upward. The Manufacturing Manager's presentation to his boss, the top divisional manager, and then to corporate management and staff, underscored the importance of finding a way to frame the proposal in terms of "larger" organizational objectives. It began, as described in the preceeding section, as he worked with R&D managers to find the right language with which to "pitch" the project and its potential. The result was a presentation similar to many of those described by Dean (1987). For example, when asked how he described the FMS to his bosses, he was very clear: "I'd be kidding you if I didn't say we leave out some of the negative things when we're trying to sell this stuff upstairs. So we forget about some of those things...." And when I asked how technical he gets in making the pitch, he responded:

> Oh, I don't try to get technical. I go on emotion as much as anything. It's got to be something that turns them on. They can visualize in their own mind that this is going to be

a good idea, it's going to solve the problem--at least in the way we've set up the problem -- and it'll get good savings. That's why I think this is attractive: it solves the technical problem and it should yield a good productivity increase.

Asked to elaborate on the "problem," he noted that the problem he was pitched (by R&D) was not necessarily the problem he pitched to his superiors; that would mean getting technical in a company in which top management decision-making was heavily influenced by financial considerations. Moreover, the problem which he saw as most important was not necessarily the problem identified by R&D: in this case, the introduction of a new machining system offered the opportunity to, in his words, "Get things under control."

Downward. An analysis of the downward framing process reiterates the skeptical regard with which the shop, and particularly the social relations in the shop, were held by the technical staff and by higher levels of division management -- even though reports from a number of participants in the process indicated that the downward framing process in this instance constituted a departure from past practice.

Past practice, as it was described in several interviews, would have R&D developing a new system or machine in a laboratory setting (often a curtained-off area in the shop for which it was destined) and "springing it on the shop", i.e., delivering the completed system or machine and, according to shop management, simply walking away. This practice left a bitter taste in the mouths of many shop managers. One general supervisor characterized the process as "leaving the shop to pick up the pieces" in terms of employee resistance, grievances from the union, downtime due to technical difficulties and delays associated with the learning curve.

The past method expressed the suspicion of both R&D and higher level management that the shop was unreceptive to change. R&D engineers, for example, frequently referred to shop management's questionable "technical competence." One staffer put it bluntly: "Most of those guys have to be dragged kicking and screaming into the 20th century." Higher level management often displayed a similar kind of suspicion, though it was generally tempered with some

compassion for the shop management's myopia: "Shop supervision had the same concern about job security that the guys operating the machines did. In other words, if you don't need as many machine operators, you don't need as many supervisors to supervise them." One manager went on to add:

> [One question] is how much of the union concerns and problems that you have come from the union and how much come from your first- and second-line management. The foreman or general says, "Charlie, you ought to go talk to the union about that. You know, that's not right."

The departure taken in this instance of new technology introduction -- and central to the downward framing process -- was not unique as far as management practice in other industries is concerned (cf., Chen, Eisely, et al 1984); however, it was unique as far as most observers in this company could see. When the FMS concept was fully elaborated and work had begun on deciding how to put the pieces together, the Manufacturing Manager chose to put assemble a "user group" with the general supervisor (in whose area the FMS would eventually reside) as its nominal leader. The general supervisor, who admitted to being opposed to the FMS project at the outset, did not proclaim great enthusiasm for it afterwards but conceded that he did see the utility of putting himself in charge. He said, in retrospect, that such a structure did force R&D to be more responsive to the needs of the shop. He added, however, that cooperation was not the only reason for his appointment: "The big boss wanted one ass to kick, and that was me."

Neither the union nor workers in the area were part of the downward framing process. The employee chosen to act as the machine operator was drawn from outside the bargaining unit.[6] Since the employees whose machines had been appropriated in the construction of the system were not furloughed, management felt it unnecessary to officially inform the union of the change or the choice of staff. In fact, the union did not become aware of the FMS until an operator (added when the FMS was extended to a second shift) made an inquiry as to whether the classification he held was the appropriate one for the machine.

Summary

The FMS case demonstrates that technological change options are filtered through a three dimensional screen created by personal, positional, and organizational objectives. The relatively decentralized development activity in this multi-divisional company enabled the division to exercise some autonomy in selecting and packaging the proposal it wanted before unveiling it to the rest of the organization. This made it possible for R&D to put forward an idea that expressed the value of their function and challenged the individuals who would be responsible for bringing it about. It also allowed the Manufacturing Manager to shape the concept to fit his personal and positional objectives. Yet, for all the jockeying, the proposal was continuously constrained -- even as it was initiated -- by the broadly-stated organizational objectives. Even while massaging the language and finessing the ROI, those organizational objectives and the structure of the organization -- especially the perceived role of divisional management -- put a clear emphasis on control over process and people.

This model of control and competence (or myopic vision) might simply be attributed to an individual manager's Theory X approach (McGregor 1960) if not for the fact that the language of this organization and the allocation of demands for performance made it appear as a logical response. Although top management did not express more than passing interest in the technical details of the proposal, the capital budgeting and review procedure for large expenditures like the FMS made it essential that the proposal be a credible one. That is, the proposal had to be backed by the right economic returns and framed so as to appear that the division had the competence with which to carry out its promises in a timely fashion. Under these conditions, it is perhaps not surprising that the Manufacturing Manager should turn first to R&D for a proposal: if the capital cost of a new approach was going to require top management review, then the proposal had to be backed by competence of a sort available only in R&D. However, R&D's technical competence was accompanied by a basic suspicion of shop management's myopia

(technical incompetence) and what it perceived as the shop-level thicket of personal obligations, outdated customs and union work rules. For R&D, new technology appeared as a surgical blade with which to excise the obstructions and let the parts flow freely.

Voiceless in the process were those whose behaviors were the object of change -- not just workers, but lower-level managers, as well. Yet, this was hardly coincidental since the problem statement made it clear that existing people and relationships were obstructing the transformation of raw materials into finished products. Rather than rearrange procedures and/or provide equipment to enable the people to do their jobs more effectively, the problem was quickly identified as one of people and procedures getting in the way of equipment, so that the latter were "not working hard enough." In this case, then, the problem of transforming employees' (i.e., machinists' and lower-level managers') potential-to-work into finished products was "solved" by the elimination of employees as active parts of the process.

Shop Programmable Machine Tools

The advent of programmable machine tools predates this study by at least 15 years. Yet, in the time since the initial experiments were made with "driving" the cutting, grinding, and shaping of a piece of metal by an external controller, the array of alternative approaches has expanded enormously. Shop programmable machine tools (or computer numerical-control, CNC) stand out as departures from the now-familiar NC and direct numerical control (DNC) machines in that each is equipped with its own small computer which can be programmed on-the-spot, on the shopfloor, by a trained operator. Since this new generation of machine tool is far less expensive than its NC or DNC counterparts and is available off-the-shelf from vendors, it is often referred to as the "throw away" machine. Graphics capabilities and a color monitor allow the operator to input data on the type of work to be done, the type of material to be machined, and the tolerances required in cutting. The computer, in turn, suggests appropriate feed rates for the cutting process and speeds for the various cutting tools. The resulting cutting angles, feeds and speeds are stored as a separate program in the computer's memory (as well as

on a floppy disk which can be removed from the machine). Once completed, the program drives the machine.

The introduction of shop-programmable equipment in this company offers a second opportunity to compare the outcomes of technological change with the expectations of the postindustrial and the labor process perspectives. This case, and the comparison, will provide further reason to integrate an analysis of the decision and development processes in order to explain what appear to be anomalous results. From the postindustrial perspective, the advent of shop programmable equipment represents something of a watershed in terms of technological possibilities. Like FMS technology, it would seem to create the possibility of greater production flexibility, e.g., the capacity to employ machine tools as multi-purpose equipment with the added opportunity to build off previously existing skills (along the lines of expert system software) without necessarily replacing the expert. Indeed, the most effective use of the equipment would seem to presuppose the presence of the expert to augment the machine's capabilities -- teaching it, in effect, beyond the threshhold of its software limits -- and then storing the lessons in the form of a reproducible program.

From a labor process perspective, by contrast, CNC machine tools hold forth the promise of further deskilling, particularly of "conventional", multi-skilled machinists (cf., Shaiken 1985; Kelley 1986). The simplifying interactive software could, in fact, be employed to completely replace the skilled machinist with a much lesser-skilled and lower-paid employee whose only knowledge of machining processes is that which is acquired in the course of learning to use the CNC equipment. If, as in this case, the manufacturer's promises hold true and operation of the machine can be advanced by a novice in a matter of days, then the expectation of rather radical changes could be the greatest attraction for the purchase and deployment of these machines.

<u>A First Look at Outcomes</u>

In mid-1986, four new shop programmable machine tools purchased from a Japanese

equipment vendor were introduced into one of the principal machine shops in the company's Parts Fabrication division. At a total cost of roughly $400,000, the four machines replaced six badly worn profile and tracing mills which, at an average of 25 years old, were judged too costly to repair. The shop in which they were placed was divided into two parts: one side contained a variety of large NC machines dedicated to relatively long production runs (i.e., in excess of 50 pieces) of aircraft parts; the other side, referred to as the "conventional side of the house," contained more traditional operator-controlled machine tools and was largely used to produce parts runs in smaller batches. The CNC equipment was brought into the conventional side and staffed by machinists who had formerly operated the worn-out machines. No jobs were lost and pay rates for the machinists remained the same. Moreover, machinists interviewed in the course of the study suggested that the new equipment represented a welcomed challenge: they enthusiastically took to the machines and reported spending many lunch and break periods discussing ways to maximize the capabilities of the new technology.

On the surface, it would appear that the CNC equipment wrought few changes in the distribution of skills or control in the shop. In fact, by contrast to the expectations of labor process theory, skilled machinists continued in the work they had previously done but did it now with the aid of more sophisticated tools -- tools which they sought to master and augment. Unlike the FMS case, for example, programming was not split off from the job of operating the machinery; instead, it was incorporated through the use of locally-programmable computers. The machinists' enthusiasm and the apparent willingness of the organization to place the new technology in their hands would suggest that management did indeed "grasp the possibilities" inherent in the technology and used them to joint advantage.

Yet, a closer examination of the decision-making processes surrounding this new technology points to a different set of conclusions. In particular, critical differences between the CNC and the FMS cases will be shown to reside in the way objectives -- particularly positional objectives -- were manifested and aligned, with the outcome described above

obscuring what was, in fact, a politically tense situation. If the FMS case was motivated by a desire to gain control over the shop, the CNC case is best characterized as an effort to gain control for the shop.

From Concept to Implementation

In comparing the decision and development processes associated with the FMS and the CNC cases, two important differences are immediately evident. First, the time frame from concept to implementation is quite short for the CNC relative to the FMS (see Figure 2 earlier). Second, a different set of organizational actors -- and, as I will go on to argue, a different set of positional objectives -- were involved in each case. These two differences are related in significant ways and, thus, before proceeding with the analysis some description is warranted.

By contrast to the FMS, the CNC equipment represented a relatively modest change in scope or technological sophistication. The machines continued to stand alone and, thus, required no sophisticated sensors to be adapted to them for purposes of linkage. The control mechanisms for machine operation did change substantially over the older hand-cranked, manually adjusted profile mills. However, since the units were relatively self-contained, their implementation implied little change in the physical processes that came before or after them.

The CNC equipment had a distinctly different "origin" than the FMS. Interviews with shop managers who had been involved in the procurement process documented that they had known of the technology for at least a year before they made a request for the machines. One shop superintendent (a third level manager) had visited several other companies which used the CNC equipment and had had discussions with potential vendors at a national equipment show in late 1984. Interviews with purchasing staff in the Parts Fabrication division suggested that the principle distinction among machines of a similar technological sophistication was largely along the lines of price. Since at the time they were requested the yen was at a low point relative to the U.S. dollar, the Japanese machines were considered more attractive.

Since the machines were relatively inexpensive and required only minor adjustments to

be made operational, development activities were limited to the selection of the appropriate models (which varied largely by capacity). Moreover, unlike the FMS which was largely built-up by R&D, these machines were purchased of-the-shelf as part of a routine equipment replacement process. Equipment replacement is an annual activity in which shop management identifies equipment in need of replacement or extensive repair, prioritizes its needs, and submits its request ("wish list") directly to divisional management. This process routinely takes place outside the purview of R&D and, in this division at least, it is part of an activity orchestrated by the Facilities and Equipment (F&E) department. Thus, the acquisition of the CNC machines did not initially attract the attention of groups outside the shop for which they were requested.

While differences in scope, expense, and accessibility are important, they offer only limited clues as to why this technology was given priority by shop management or why it was deployed the way it was. A series of lengthy interviews with representatives of shop management and the F&E department revealed that the central attraction of the CNC machines for shop management resided in its potential to gain a measure of control for the shop over the work environment, especially the scheduling of jobs. A significant chunk of the work performed in the conventional side of the shop consisted in "emergent" jobs, i.e., new parts being produced in relatively small numbers or tested for use elsewhere. Normal flow conditions for this work, they argued, often failed to take into account the arrival of "blue streak" (high priority) or AOG orders (i.e., parts needed by a customer with an "airplane on the ground"). The unpredictable arrival of blue streak or AOG work, as well as competing demands from various sources for small production runs or for the creation of prototypes, led to a great deal of negotiation, juggling, and, occasionally, overt conflict between shop management and the internal and external customers making claims on the shop's machining capacity.

Adding to the tension experienced by shop management -- who described the situation as "chaotic," "ulcer-producing," and "impossible" -- was the shop's dependence on external

departments for the plans and programs necessary to meet the orders they received. In particular, the Resource Planning and the NC programming groups, located in a separate set of offices, were the object of many complaints from shop management. These groups exercised a claim to "configuration control" which directly affected shop management's ability to accomodate the demands of its various customers. Configuration control, briefly put, involves control over plans, programs, and specifications for the large variety of parts machined in the fabrication division. When parts were formerly cut on numerically-controlled (NC) equipment, Resource Planning directed the NC programming group to write or retrieve a program for making the part, distributed the tape to the appropriate portion of the shop on the basis of a pre-determined priority schedule, and when revisions to existing program were required (e.g., as a result of modification to fit a particular airplane or airplane customer), the Resource Planning group would oversee the documentation of revisions. As such, Resource Planning played traffic cop in directing the flow of parts and programming, as well as librarian in revising, storing and retrieving blueprints, programs and documents.

The point of the CNC equipment, thus, was a short-circuiting of the otherwise highly centralized system for planning, scheduling and controlling the production process. In effect, when the shop acquired the machines, it also acquired the ability to write its own programs, to store them locally, and to directly influence the scheduling of its work load. Most importantly, it effectively cut the Resource Planning organization out of the loop.

Aligning Objectives

The more formal process of framing the request in the language of organizational objectives began in 1985. As part of the equipment replacement process, the shop was expected to draft a five-year plan for equipment purchases. Prior to 1985, each five-year plan had included a request for replacement of a number of badly worn machine tools with newer but largely similar versions. Starting with the 1985 plan, however, the request specified "CNC" equipment; since CNC was largely undefined, it was not particularly clear that "shop

programmability" was the underlying desire. The shop request went forward with the following unexceptionable problem statement: "Existing equipment is over 20 years old. [It is] experiencing 10% downtime. Worn beyond repair." The solution statement, accompanying a technician's review of the equipment, concluded: "Purchase [CNC] machining centers that allow operators to input data. This will eliminate layout time and increase productivity. ...[W]ill allow 4 machines to replace 6."

In the normal course of its duties, the F&E department helped concoct the formal proposal, including calculating the payback periods for the investment. The payback figures appeared respectable -- 18 months for one pair of larger capacity machines and 10 months for a smaller pair -- but, again, there was some question regarding the accuracy of the calculations. When asked how those figures were arrived at, shop managers admitted that they were "based as much on guess as on fact." To that was added the admission that there were never more than 4 people operating the six machines being replaced (i.e., due to the extensive downtime of the older machines). Still, the F&E staff followed the standard procedure of producing transparencies to form the basis of the proposal to divisional management. (The F&E department recommends a specific number of transparencies for each $100,000 in capital requested). After divisional management completed its annual review and approved the proposal, the bid specifications were drawn and the equipment was eventually purchased.

<u>Framing Downward, Not Outward</u>

Since shop management found language and measures to justify the CNC equipment to divisional decision-makers in terms of organizational objectives, the potential for conflict between and negotiation over positional objectives was minimized <u>prior</u> to the machines' arrival. However, this did not mean that shop management was inattentive to the existence of other interests. Most importantly -- and in direct contrast to the FMS case -- the proponents made a concerted effort to build support for the new machines among the workers who would eventually operate them.

Downward. Replacing worn out equipment and quietly (but quickly) gaining a measure of independence from other departments may have been part of plant management's rationale for acquiring the new machines, but the manner in which they were selected and deployed was profoundly affected by social organization at the level of the shopfloor. In the words of one manager close to the process, the CNC equipment was also selected because it would "preserve and extend" the skills of machinists already in the shop. In this instance, shop management's perspective could be viewed as simple rhetoric but was, in fact, accompanied by efforts to involve the machinists in the area: acknowledging, in effect, labor's positional interests. Two of the workers who ultimately came to staff the machines were consulted in advance about the feasibility of this kind of equipment and the four workers who were assigned the machines were sent out for special training with the vendor several weeks before it arrived. The significance of this move is greater because, as noted earlier (see also Kelley 1986; and Jones 1982), the machines do not presuppose a lengthy apprenticeship in the range of machining skills in order to be run adequately.

Interviews with the CNC equipment operators revealed that shop management's action was appreciated but, at the same time, it was also expected. Conventional machinists are traditionally very protective of their skills and resist the incursion of new control systems, especially when they diminish operator control. In this instance, however, the impact on skills was discounted as a source of contention. For example, when asked his opinion about the CNC equipment, one of the operators described them as an extension of past technology:

> It's really something the way it reduces the time we used to spend doing set-ups. But it doesn't require any less skill because you can override the controls. You can also make a part faster for a customer because you don't have to sit and wait for NC programming to do their thing. We spend a lot of time trying to figure out how to program them to do trickier cuts.

Another machinist readily admitted that simple operation of the machines could be possible by

someone who had no experience with conventional machine tools but, he added, shop management's closeness to the work being done in the area made them "aware of what it takes to get the most out of this equipment." That awareness, he suggested, derived in large part from the fact that several of the higher level supervisors in the shop had begun work as hourly machinists there. Another operator added, however, that any attempt to force a new piece of equipment into the shop without "smoothing it out with the guys" would likely have set off at least a mild confrontation.[7]

Whether motivated by regard for machinists' skills, commonality of experience, or desire to avoid confrontation, shop management made local conditions a central factor in the selection and deployment of the new technology. That approach -- corroborated by both managers and workers -- had a substantial pay-off (as described earlier) in the enthusiastic response of the area machinists.

Representatives of the compensation office within Industrial Relations, however, were not nearly so sanguine about the about the introduction of the new technology. Their response, which could easily have been scripted by labor process theorists, emphasized the "deskilling" of the work and, therefore, the devaluation of the job. The compensation representative with responsibilities for this shop argued strongly that the wage rate should have been lowered as a result of the new technology:

> The skill level required to operate an CNC machine is really not a heck of a lot more difficult, and I'm going to oversimplify here, than a housewife who dials up the oven and says, "I want 325 degrees." She puts whatever she wants in there and the oven does its thing. So, anyway, we felt that we'd overpaid on the CNC.

The new technology may have appeared to require less skill, but compensation, like other groups with distinct positional interests, had been effectively kept out of the loop of the decision process.

Outward. Although neither Industrial Relations nor Resource Planning had been aware of

the events that led up to the acquisition of the CNC equipment, representatives of the latter group resolved not to let it happen again. For many of those involved, including the R&D group, what transpired was further evidence that "the shop ought not be left to its own devices." In the words of one well-placed "outsider": "What you see there is a demonstration of how oriented shop management is their own small world and to their personnel. And, obviously, they grew up in the shop. They came up through there. So, when you analyze what they tell you, you have to remember where they came from." Within six months after the equipment arrived, the aggrieved stakeholders (which by that time included Resource Planning, NC programming, and Manufacturing Engineering) began meeting to formulate a response. According to one engineer involved in the process:

> Just recently, manufacturing engineering recognized that they should be in the loop of acquisition of new technology. What we're doing now is getting the procedure changed so ... we have a say because we're closer associated to the prime divisions as to what we expect in the future. I think in that regard we know a little bit more than the shop. So, at lest we'll have a say in the equipment they purchase as to what it should be.

Thus, in finding a means to satisfy its positional objectives, shop management attempted to sever a few of its external dependencies. What might have appeared as a rational process quickly generated a decidedly political response.

<u>Summary</u>

In this instance of technological change, we see several important points of similarity and contrast with the FMS. Like the FMS, the selection of technological possibilities was profoundly influenced by different actors' personal and positional objectives. Shop management, perceiving its objectives in terms of independence from other divisional groups, sought to acquire equipment which gave it an added measure of control over the production process. To achieve those ends, it had to frame the proposal in terms of extant organizational objectives <u>and</u> frame the request in terms that would either accomodate or avoid others with conflicting objectives.

Unlike the FMS case, however, differences in origin, cost, review procedure and the scope of the change led to a situation in which the social environment of the shop influenced the selection and implementation of the new technology. In a demonstration of what R&D labelled "myopia," shop management chose to actively align positional objectives ignored in the FMS case -- most particularly those of shopfloor employees. In this sense, shop management marshalled the support of area machinists in order (1) to counteract what it perceived to be the hypermetropia (farsightedness) of R&D and (2) to meet the performance demands placed on it. Thus, rather than operate from a model which identified subordinates as the source of uncertainty, shop management identified peer and superior organizations as the principle obstructions in its model of the transformation process.

Implications for the Two Perspectives

The data presented offer a measure of support for both the postindustrial and the labor process perspectives on technological change -- but with major exceptions in each case. Those exceptions, I will suggest, are not simply the product of the particularities of the cases themselves, but point up several important shortcomings in each of the perspectives. In this section, I will begin with an assessment of what the perspectives explain and what they do not and then conclude with the broader theoretical implications of this research.

In the FMS case, the opportunity to gain control over shop activities was an important attraction for divisional management, especially since the new technology promised to eliminate "heads," worker discretion and the customs and obligations which had accumulated over the years. These attractions certainly coincide with what Braverman (1975), et al., have suggested as central dynamics behind technological change in capitalist industry. Yet, the detailed examination of the FMS case also revealed that, for both divisional management and R&D, the desire to enhance control over the shop as a whole -- including workers and supervisors -- represented a broader attraction. The choice of technological alternatives was no less influenced by power considerations than labor process theory would predict, but restriction of the scope of

the analysis to the point-of-production (i.e., impacts on workers exclusively) would have resulted in a partial understanding of the objectives which lay behind the selection and configuration of this new technology. Equally important, failure to investigate the process of change from concept through implementation -- including attention to the characteristics of different groups involved in the development process -- would have forced the analysis to infer intent from outcome. This is a hazardous approach when one considers the complex and often non-rational character of the decision-making process.

While the FMS case gives credence to at least one of the major assumptions of the postindustrial perspective -- the widening array of technological possibilities available to firms -- it also demonstrates quite vividly how quickly options are narrowed. The narrowing process in this case involved two distinct influences: (1) the overarching organizational objectives (especially "cutting costs" and "losing heads") which created narrow evaluation criteria (e.g., specific return on investment benchmarks); and (2) the persistent emphasis on control put forth by divisional management and the R&D function. While the accumulation of new systems like the FMS may eventually force this organization and others like it to recognize the importance of a skilled, committed, and flexible labor force, there is much reason to believe that the organizational, positional and personal objectives identified in this case will be extremely resistant to change. Moreover, absent detailed analysis of how ideas enter organizations, how they are refracted by organizational structures, and how they are translated into concrete systems, discussions of technological "possibilities" will continue to be carried on in a vacuum.

The CNC case also offers important insights. The manner of purchase and implementation of shop programmable equipment may not entirely contradict expectations drawn from a labor process perspective, but it cannot be readily explained by the theory either. While the theory would suggest that control was the objective, the case analysis shows that shop management was particularly sensitive to workers' positional interests and accomodated them with advance

consultation, extensive training, and the maintenance of machinists' discretion in the use of the equipment.

At the same time that the CNC equipment appeared to represent the seizure of an important technological possibility -- in line with the postindustrial perspective -- the actual acquisition and use of the machines was motivated by objectives that appear to have little to do with an organizational "awakening." Rather, the CNC machines offered the possibility for shop management to quietly cut itself loose from what it perceived to be obstructions to its narrowly defined responsibilities. Again, the accumulation of similar equipment may, over time, lead to greater organizational flexibility, but the mobilization of aggrieved stakeholders in this firm augers poorly for that outcome.

Broader Implications

In light of the differences between two cases drawn from the same company and their uneven support for two major theoretical perspectives on technological change in industry, it is tempting to conclude that decision-making around new technology is a rather conjunctural or indeterminate process. Yet, I would argue, there is an important theoretical lesson to be drawn from this research: the necessity of distinguishing between lateral and hierarchical dimensions in the politics of technological change.

Lateral Dimension

Both cases demonstrate the significance of technological change as a political event within organizations. In line with earlier characterizations of the politics of organizational decision-making (cf., Simon 1955; Pettigrew 1973; and Pfeffer 1977), these cases document the extraordinary attention paid to acquiring and exercising influence over the expenditure of organizational resources. This was amply demonstrated in the intense efforts made by various groups to identify problems and solutions in their own domain, frame them so as to incorporate (or avoid) the positional objectives of competitors, present them as organizationally significant, and garner resources with which to change relationships and behaviors by way of

new equipment and processes.

This <u>lateral</u> dimension to organizational politics is not, however, unconstrained. While competing groups seek to fulfill their personal and/or positional objectives by means of technological change, they do so within constraints imposed by language and criteria associated with organizational objectives. In the organization under study here, the language and criteria were relatively clear. Thus, proposals put forth for change were especially attentive to the appearance -- if not always the reality -- of reduced costs and labor. Even though "finessing" ROI calculations and granting strategic concessions to competing groups rendered the process less tidy, it did not diminsh the fact that organizational objectives delimited change possibilities to those which could make a claim to reducing costs and labor.

Moreover, the lateral dimension to organizational politics underscores the importance of alignment among organizational, positional, and personal objectives in the change process. Though organizational objectives establish the limits within which problems must be framed, positional objectives are directly expressed in the selection of problems to be framed. In the FMS case, for example, R&D put forth a problem and a solution which reflected its positional objectives but did so in such a way as to maximize the overlap between its proposal and the positional objectives of divisional management <u>and</u> the personal (career-minded) objectives of the Manufacturing Manager. In the CNC case, shop management sought simultaneously to align its objectives with those of divisional management <u>and</u> to disguise its objectives from other groups.

Taken together, organizational objectives and the need for alignment result in a contest for resources which forces originators of change proposals to be vigilant in their efforts to present their proposals in a language which is structured by organizational objectives and capable of either incorporating or besting the proposals of competitors. In this organization (and, arguably, most other manufacturing firms) such framing must take the form of justifications which are comprehensible to top decision-makers whose attention is directed to concerns which

are: (1) often quite different than those of proponents for change (e.g., concerned with shareholders, market analysts, etc.); and (2) who are not likely to be especially aware of the circumstances or conditions which pertain in the group (division, plant) which is making the proposal (cf., Donaldson and Lorsch 1983). Under these circumstances, the organizational objectives they establish and the criteria for approval they put in place can often force proponents to: refrain from presenting proposals which serve positional objectives but which canot pass muster under traditional criteria (cf., Kaplan 1986; Gold 1983); rely on their own personal credibility to support a proposal for which the numbers are not convincing (cf., Dean 1987; Maidique 1980); or attempt, as I have described elsewhere (cf. Thomas 1987) to engage in a process of "creative rebellion," i.e., squirrel away pockets of money to accomplish changes which might not receive approval from above or extend the purchase of a larger expense over several budget cycles.

The lateral dimension to organizational politics and decision-making around technology has serious implications for theories of technological change. First and foremost, it suggests that in the absence of altered organizational objectives and criteria, traditional measures justifying investments will remain and, if the FMS case is any guide, they will narrow the range of technological possibilities to those which can either be justified in terms of cost reduction or lost heads. That is, criteria which encourage production managers and engineers to pursue options quite similar in substance to those predicted from labor process theory. Moreover, as technologies continue in the direction of integrated systems and cells, the application of traditional criteria will force more champions of technological change to "creatively rebel" -- characterized most directly by "saying what you hear in order to get what you want" -- or refrain from changes which might make sense (e.g., in the longer term) but which cannot be supported by an individual's credibility or finessed calculations.

Second, it suggests that the scope of technological change will be directly related to the level at which it is initiated. What is perhaps most ironic about the two cases reported in this

paper is the fact that the solution oriented toward making the most of existing skills and human resources was the one made farthest down in the organization. The one least concerned with the human implications of change originated at some remove from the shopfloor. Given that more and more change will involve systems and cells -- and that organizations are feeling greater pressure to integrate isolated cells -- it will increasingly be the case that, in traditional firms at least, less attention may be paid to the human and organizational implications of technological change than ever before.

Hierarchical Dimension

While the lateral dimension of organizational politics focuses on the competition among peer groups to garner resources in order to enact solutions, the hierarchical dimension directs our attention to the behaviors, relationships and processes which are perceived to be the source of problems and, therefore, are the object of change. In other words, since lateral competition or conflict is only engaged after problems are found, we are compelled to investigate where problems come from: how they are "found" or formulated.

A brief look back at the FMS and the CNC cases gives us some useful clues as to how problems were found in one manufacturing company. In the FMS case, divisional management and R&D together broadly identified the shop as the source of the problem, i.e., existing procedures, relationships and task structures were seen from a level above and outside the shop as impediments to the technical rationality (Thompson 1967) of the production process. But, rather than engage shop personnel in an examination of how the human or social organization of work might be altered to facilitate the translation of the potential-to-work into finished products, a decision was made to eliminate the human element and impose, from the outside, a mechanical solution. The problem, the solution, and the manner of implementation speak volumes about two critical elements of divisional management's model of the human problems of transformation: (1) the perceived ability or willingness of subordinates to participate in a reorganization of their own work; and (2) the power of higher-level management to impose

their own solution.

In the CNC case, by contrast, shop management identified relationships with other parts of the organization as the problem. From the shopfloor perspective, the human problem of transformation did not involve questions of commitment or willingness on the part of workers but, instead, involved the provision of resources and authority to enable the shop -- supervisors and workers -- to get the work done. New technology, in the form of locally-programmable machine tools, provided the instrument through which a very diferent model of the transformation process could be enacted.

If, as these two cases demonstrate, there can be very different models of the human problem of transformation in the same organization, then an important proposition derived from this analysis can now be stated directly: <u>the hierarchical level from which a change proposal originates and the normative assumptions about the human problems of transformation which underlie it will both materially affect the selection of technological possibilities</u>. This proposition suggests that, by contrast to the labor process perspective, organizations and organizational processes do influence the selection and implementation of new technology -- with skill enhancement and employee participation constituting real alternatives to the "control" imperative. But, as a caution to the postindustrial perspective, it suggests that technological possibilities alone are unlikely to dislodge firmly held and organizationally sanctioned normative assumptions about the human problem of transformation.

Footnotes

1. Though this level of analysis makes it difficult to address the broader competitive or ecological processes which may, in fact, limit the degrees of freedom available to individual firms (Hannan and Freeman 1974; Tushman and Anderson 1986), it has the advantage of focusing attention on actual behavior in the firm -- rather than on "systemic" processes (cf., Edwards 1979, and Gordon, Edwards and Reich 1982) which may be quite powerful but which are also difficult to demonstrate empirically.

2. The company's name, as well as that of the interviewees, will not be disclosed to assure the anonymity of each.

3. A third case -- the development and implementation of a robotized assembly cell -- is omitted here due to space limitations. A brief description is available in Thomas (1988).

4. Since case-study based research invariably raises questions about the generalizability of the findings, we build the analysis with two explicit reservations in mind. First, the aerospace industry varies from other manufacturing industries in its emphasis on batch or low-volume, high value production. This biases the organization's manufacturing research and development activities in the direction of technologies which enable it to produce high quality precision components, rather than repetitive, high volume activities. It will become apparent in the case studies, however, that the diversity of manufacturing processes in this company (e.g., parts fabrication and machining, as well as assembly) enabled us to include a case of technological change targetted at high volume production. Second, because the company engages in a considerable amount of in-house product <u>and</u> process development, it maintains an extensive R&D apparatus. The process or manufacturing R&D function is largely decentralized to the level of the operating divisions. Thus, by contrast to less diversified firms which may centralize their manufacturing R&D activities, this company tends to distribute them; however, budgetary review for major capital equipment purchases and development projects continues to take place at the corporate level.

Beginning and ending points were chosen arbitrarily: the beginning was designated as the first formal (written) reference to a particular problem (or solution) which could be linked to one of the projects; and the endpoint was chosen as the date in which the new equipment was brought formally into production.

5. The categories of development are ones I created for descriptive purposes and are not necessarily the same as interviewees used.

6. He had been working as an NC programmer and therefore had been a technician (or "tech" as they are referred to in the company) and was officially downgraded to hourly machinist. Given the system of wage scales in the company, the move had no impact on his weekly earnings.

7. The union was not, however, informed of the impending arrival of the new equipment. For an examination of the tensions created by shop management's "informal consultation" with employees, see Thomas (1988).

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